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(54) **PLASMA DISPLAY PANEL AND ITS MANUFACTURE**

PLASMAANZEIGETAFEL UND HERSTELLUNGSVERFAHREN DERSELBEN

ECRAN A PLASMA ET FABRICATION DE CE TYPE D'ECRAN

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(56) References cited:
EP-A- 0 131 389 JP-A- 2 273 439
JP-A- 6 243 788 JP-A- 7 065 729
US-A- 3 837 724 US-A- 4 207 488

• **PATENT ABSTRACTS OF JAPAN vol. 096, no.**
007, 31 July 1996 & JP 08 077930 A (PIONEER
ELECTRON CORP), 22 March 1996 -& US 5 703
437 A (PIONEER ELECTRONIC CORPORATION,
TOKYO, JAPAN) 30 December 1997

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Description

Field of the Invention

- 5 **[0001]** The present invention relates to an AC type surface-discharge plasma display panel, referred to hereinafter as a PDP, and its driving method.

Background Technology

- 10 **[0002]** PDPs are self-luminescent type display devices advantageous in the display brightness, and have been attracting attention as a display device for replacing CRTs, owing to their potentiality of large screen size and their high-speed displaying capability. Particularly, surface-discharge type PDPs suitable for color displays employing fluorescent materials have been rapidly increasing their application areas in the field of television picture including the high definition television.

- 15 **[0003]** Fig. 1 shows a decomposition perspective view of a general surface-discharge type PDP, where is shown a basic structure of a part which corresponds to a single picture element EG. The PDP shown in Fig. 1 is of a three-electrode structure called a reflection type in the classification of fluorescent materials arrangement, where are a pair of glass substrates 11 & 21; pairs of display electrodes X & Y provided thereon extending in the lateral direction in parallel adjacently to each other; a dielectric layer 17 for an AC drive which utilizes wall charges for a discharge; a
20 protection film 18 formed of magnesium oxide (MgO); address electrodes A orthogonal to display electrodes X & Y; separator walls 29 which are like lines in parallel to address electrodes A when looked down; and fluorescent material layers 28 to display primary colors, red (R), green (G) and blue (B), respectively.

- 25 **[0004]** Separator walls 29 divide an internal discharge space 30 into unit lighting-areas EU in the extending direction of display electrodes X & Y, and define the gap dimension. Fluorescent material layers 28 are provided between each separator wall on a glass substrate 21 opposite from display electrodes X & Y in order to avoid ion bombardment of the surface discharge, and emit a light by being excited by an ultra violet light generated in the surface discharge. A light emitted at the surface plane (a surface which faces the discharge space) penetrates dielectric layer 17 and glass substrate 11, etc. so as to radiate outwards.

- 30 **[0005]** Display electrodes X & Y being arranged on a display surface H which opposes fluorescent material layers 28 are formed of a wide and transparent electrode 41 and a narrow metal film (a bus electrode) 42 for supplementing the electrical conductivity, in order to perform the surface discharge in a wide area and to minimize the light shielding. Transparent electrode 41 is formed of metal oxide, such as ITO (indium oxide) and NESA (tin oxide). A typical example of this kind of AC type surface discharge PDP was disclosed on European Patent Application No. 0 554 172A1.

- 35 **[0006]** For a thus constituted PDP, its smoother surface plane is desirable in securing a uniform discharge characteristics and the transparency.

- 40 **[0007]** Accordingly, dielectric layer 17 is generally formed of a single glass layer such that a low-melting temperature lead-glass (containing about 75% of PbO) having a melting temperature of, for example about 470° C, is fired at a temperature 600° C adequately higher than its softening temperature. The high temperature firing at the temperature adequately higher than its softening temperature allows the glass material to flow during the firing so as to accomplish
a glass layer having a flat surface.

- 45 **[0008]** In driving PDPs, the equality of the electric potential status between display electrodes X & Y is deteriorated when the pulse widths of the driving pulses applied to the display electrodes X & Y in pair are subtly imbalanced or when such a sequence is constantly employed that the number of the pulses applied to one of display electrodes is more than those to the other one. That is, a DC voltage of, for example, about 200 V of the same polarity comes to be applied thereto for a considerable period. On the other hand, the gap between display electrodes X & Y is as small as 100 µm. And, the dielectric layer 17 to insulate them contains PbO as described above. It is estimated that the surface of dielectric layer 17 upon whose surface a discharge takes place attains a considerably high temperature. Really, the glass surface reaches 70°C. Moreover, indium and tin included in the transparent electrodes are chemically unstable, and also the copper of the metal electrodes are materials which easily penetrate into dielectric layer 17 so as to cause
50 electro-migration. Combination of the electrode material, insulating material, the applied high electric field and the high temperature satisfies the condition to accelerate the electro-migration.

- 55 **[0009]** A long term operation under such a condition of the prior art structure progresses the electro-migration of display electrodes X & Y so that a tree-like spike is grown in dielectric layer 17 from transparent electrode film 41 of one of the display electrodes to transparent electrode film 41 of the other one of the display electrodes. Therefore, there was a problem in that the insulation resistance was locally decreased, whereby a unit lighting area EU, that should not light, erroneously lights. It is impossible to completely remove the imbalance of the applied voltages which is the cause of the electro-migration. Document EP 0 131 389 discloses a gas-filled display panel wherein the insulating transparent coating covering the electrode is made of a lead-free glass material.

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DISCLOSURE OF THE INVENTION

[0010] The present invention is in consideration of such problems, and aims at a prevention of deterioration of the electrically conductive films constituting display electrodes X & Y so as to enhance the reliability of the display.

[0011] In accomplishing the present invention the present inventors have searched for dielectric materials suitable to cover the above-described electrically conductive films. Consequently, it was found that a utilization of a glass material containing ZnO allows a great reduction of the deterioration of electrically conductive films caused from the electro-migration.

[0012] The PDP according to the present invention is an AC-type plasma display panel comprising: a plurality of display electrodes formed of a transparent electrically conductive film or a multiple-layer of a transparent electrically conductive film plus a metal film narrower than the transparent electrically conductive film at least upon one of the substrates; and a dielectric layer covering the above-described display electrodes from a discharge space, wherein the above-described dielectric layer is a glass layer of double layer structure having a lower layer contacting the display electrodes and an upper layer not contacting the display electrodes; the lower layer is formed of a ZnO-containing glass material containing substantially none of lead; and the upper layer is formed of a PbO-containing glass material having a softening temperature lower than that of the lower layer.

[0013] Moreover, after the dielectric layer employing the ZnO-containing glass material is coated over the whole display electrodes and a sealing process is completed, the dielectric layer that covers the ends of the display electrodes are removed.

Brief Description of Drawings

[0014]

Fig. 1 is a decomposition perspective view of a general surface-discharge type PDP;
Fig. 2 is a cross-sectional view illustrating main portion of the structure of a PDP related to the present invention;
Figs. 3A to 3C schematically illustrate the PDP at the manufacturing steps; and
Fig. 4 is a graph showing the relation between deterioration of a transparent electrically conductive film formed of ITO and the dielectric materials.

Description of the Notations:

[0015]

1 PDP (Plasma Display Panel);
10 electrode substrate;
11 first glass substrate;
17 dielectric layer;
17A lower layer;
17a electrode terminal protecting layer;
17B upper layer;
21 second glass substrate;
30 discharge space;
31 sealant
41 transparent electrically conductive film;
41a end (end of display electrode);
42 metal film;
171 glass layer containing ZnO; and
X & Y display electrodes.

Best Modes for Embodying the Present Invention

[0016] Structures of the PDPs according to the present invention are not essentially different from the prior art PDP shown in Fig. 1 except for below-described dielectric materials and the fabrication conditions related thereto. These are hereinafter described with reference to a cross-sectional view shown in Fig. 2.

[0017] PDP 1 according to the present invention is a surface-discharge type PDP of three-electrode structure, where a pair of display electrodes X & Y and address electrode A correspond to a unit lighting area of the matrix display.

[0018] Display electrodes X & Y are provided on a first glass substrate 11 placed at a front side, and are insulated

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from a discharge space 30 by an insulating film 17 for an AC drive. Thickness of insulating film 17 is about 20 to 30 μ m. Upon surface of insulating film 17 is provided an about several hundred nm thick MgO film 18 as a protection film.

[0019] Display electrodes X & Y are formed of a wide belt-like transparent electrically conductive film 41 and a narrow bus metal film 42 stacked on its outer edge in order to supplement the electrical conductivity. Transparent electrically conductive film 41 is formed of an ITO film (indium oxide film) of about several hundred nm -- 1 μ m thickness; and bus metal film 42 is formed of a thin film of a three layer structure of Cr/Cu/Cr, for example.

[0020] Upon a second glass substrate 21 to be placed at the back side are arranged address electrodes A for selectively lighting the unit lighting area so as to cross display electrodes X & Y. Fluorescent material 28 to emit a pre-determined color, that is three primary colors RGB, is provided to cover the inner surface of the back panel including the upper surface of address electrodes A.

[0021] Dielectric layer 17 of the present invention is formed of a lower layer 17A to contact transparent electrically conductive film 41 and bus metal film 42, and an upper layer 17B stacked on lower layer 17A. Lower layer 17A is formed of a glass material containing ZnO and having a softening temperature of 550 -- 600° C; and upper layer 17B is formed of a glass material having a softening temperature of 450 -- 500° C, which is lower than that of lower layer 17A, including PbO. The thicknesses of lower layer 17A and upper layer 17B are of the same order. The softening temperature is defined as a temperature at which the viscosity of the glass material becomes 4.5 x 10^{6.5} poise (1 poise = 0.1 Pa·s).

[0022] Hereinafter is described a fabrication method of a PDP 1 of the present invention, mainly about the formation steps of dielectric layer 17. Figs. 3(A) to 3(C) schematically illustrate manufacturing steps of the PDP. At first is described the outline of the steps. PDP 1 is fabricated in accordance with sequential steps such that each glass substrate 11 & 21 is provided with predetermined structural elements, respectively, so as to make a front electrode substrate (a half panel) 10 and a back electrode substrate 20; next, electrode substrates 10 & 20 are stacked with each other so as to be sealed; and next, internal gas is exhausted; and a discharge gas is filled thereinto.

[0023] Hereinafter described is a fabrication method of first glass substrate 11. First glass substrate 11 is an about 3 mm thick soda-lime glass plate coated with silicon dioxide film (SiO₂) on one of its surfaces. Upon the SiO₂-coated surface are formed display electrodes X & Y by sequentially forming transparent electrically conductive film 41 and metal bus electrode by film-formation using a vapor deposition or sputtering method, and patterning with a lithography method. Next, upon the surface of first glass substrate 11 is uniformly coated, so as to cover entire length of display electrodes X & Y by means of screen printing method, a glass paste having mainly a glass material containing ZnO but substantially none of PbO, for example, the glass material (softening temperature 585° C) having the contents shown in Fig. 1 or the glass material (softening temperature 580° C) having the contents shown in Fig. 2.

TABLE 1

CONTENTS OF LOWER LAYER GLASS MATERIAL (CONTAINING ZnO)	
ZnO	30 -- 40 Wt %
B ₂ O ₃	10 -- 20 Wt %
SiO ₂	-- 5 Wt %
Bi ₂ O ₃	20 -- 30 Wt %
Softening Temp.: 585 ° C	

TABLE 2

CONTENTS OF LOWER LAYER GLASS MATERIAL (CONTAINING ZnO)	
ZnO	30 -- 40 Wt %
B ₂ O ₃	15 -- 25 Wt %
SiO ₂	-- 8 Wt %
Bi ₂ O ₃	20 -- 30 Wt %
CaO	7 -- 17 Wt %
Na ₂ O	0 Wt %
Softening Temp.: 580 ° C	

Next, the dried paste layer is fired at a temperature, for example 550 -- 530° C, near its softening temperature so as to form lower layer 17A and an electrode terminal protecting layer 17a while foaming is prevented therein. In order to prevent deformation of glass substrate 11 it is preferable that the firing temperature is lower than 590° C as described

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above. Accordingly, the softening temperature of the upper layer 17B is set adequately lower than 590° C.

[0024] The portion, for indirectly facing the discharge space, of thus fired glass layer 171 containing ZnO is the lower layer 17A; and a portion for covering the ends of the display electrodes is called the electrode terminal protecting layer 17a. Electrode terminal protecting layer 17a also plays a role to protect oxidization of display electrodes X & Y caused from the reaction with moisture during the subsequent heat treatments.

[0025] In the case where the firing temperature of lower layer 17A is lower than the vicinity of its softening temperature, even if a chemical reaction is generated to accompany a foaming caused from the contact of the glass material to the copper in bus metal film 42, no bubble so large as to cause insulation breakdown is generated because the foam does not grow. However, if the firing temperature of lower layer 17A is low, the surface plane (upper surface) becomes uneven (a rugged surface having surface roughness 5 -- 6 μ m) reflecting the glass grain size. The rugged surface deteriorates the transparency resulted from the scattering of the light.

[0026] Therefore, upper layer 17B is formed upon lower layer 17A in order to flatten dielectric layer 17. As the upper layer 17B there is coated a paste material having its softening temperature lower than the material of lower layer 17A, i.e. a paste whose main component is a glass material containing PbO (softening temperature 475° C), for example, of the component shown in TABLE 3. At this time the area to be coated excludes the above of the ends (to become the terminals) of display electrodes X & Y. This is from a consideration to facilitate afterwards the fabrication steps to expose the ends of display electrodes X & Y. These steps will be described later again.

TABLE 3

CONTENTS OF UPPER LAYER GLASS MATERIAL (CONTAINING PbO)	
PbO	70 -- 75 Wt %
B ₂ O ₃	-- 20 Wt %
SiO ₂	10 -- 20 Wt %
Softening Temp.: 475 ° C	

[0027] Next, the dried paste layer is fired at a temperature higher than its softening temperature but lower than the firing temperature of lower layer 17A, (for example, 530° C) so as to form upper layer 17B [Fig. 2(A)]. Due to the firing temperature higher than the softening temperature of upper layer 17B, the glass material of upper layer 17B flows during the firing operation so as to form a flat upper layer 17B whose surface roughness is about 1 -- 2 μ m (that is the dielectric layer 17 formed of the two layers together).

[0028] Moreover, owing to the firing temperature of upper layer 17B lower than the firing temperature of lower layer 17A, the foaming in lower layer 17A can be prevented. Upon thus fabricated electrode substrate 10 is formed concurrently the layer 17a which serves as both a dielectric layer and an electrode terminal protecting layer, as described above; therefore, the simple layer structure allows excellent yield; moreover, the process to expose the electrode terminals is easy as will be described later, and is suitable in fabricating PDP 1.

[0029] For the glass material including ZnO, it is comparatively difficult to lower the softening temperature; therefore, the softening temperature is lowered by adding Bi₂O₃ thereto. The softening temperature can be lowered by adding alkaline metal oxides such as represented by Na₂O as shown in TABLE 4. Softening temperature of the glass material having the contents shown in TABLE 4 is 550° C.

TABLE 4

CONTENTS OF LOWER LAYER GLASS MATERIAL (CONTAINING ZnO)	
ZnO	20 -- 40 Wt %
B ₂ O ₃	15 -- 25 Wt %
SiO ₂	-- 11 Wt %
Bi ₂ O ₃	20 -- 20 Wt %
CaO	-- 4 Wt %
Na ₂ O	-- 5 Wt %
Softening Temp.: 550°C	

[0030] After lower layer 17A and upper layer 17B are sequentially formed so as to provide dielectric layer 17 as described above, a protection layer 18 is formed by electron beam sputtering, etc. of MgO as well-known so as to complete the fabrication of the front glass substrate.

[0031] Next, a back electrode substrate 20 fabricated otherwise and front electrode substrate 10 are stacked to face

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each other so that they are sealed together by fusing sealing-glass 31 which acts also as an adhesive [Fig. 3(B)]. In practice, the sealing glass 21 is provided in a frame shape by means of screen print on one or both of the electrode substrates before they are stacked; then, they are stacked and fuse-sealed. At this time, the fusing temperature is set at such a temperature that does not deform separator walls 29, for example about 450 C. During this fusing of sealing

5 glass 21 electrode terminal protection layer 17a prevents the ends of display electrodes from the oxidization. [0032] Next, electrode terminal protection layer 17a exposed outside the panel is removed by a chemical etching employing, for example, nitric acid so as to expose the ends 41a of display electrodes X & Y [Fig. 2(C)]. At this time, the ends of display electrodes X & Y being formed of a single layer of metal film 42 only are not etched by the nitric acid solution when exposed. If a discharging is to be performed during exhausting the inside of the panel, the etching

10 of electrode terminal protection layer is performed before the exhausting step. After the PDP is completed, this exposed portion is connected via an isotropic electrically-conductive film and a flexible cable to an external driving circuit. [0033] Fig. 4 is a graph to present a relation between the deterioration of ITO film and the dielectric material. That is, there were prepared a sample in which display electrodes X & Y are covered with the glass material containing ZnO having the contents of TABLE 1, and another sample coated with the prior art glass material containing PbO having

15 the contents of TABLE 5. Softening temperatures of both the samples were chosen almost equal. Lengths of free-like spikes were measured by a microscopic observation, while accelerated life tests were performed on these samples applied with DC voltages of the driving pulses multiplied by an acceleration factor of the driving pulses, i.e. 100V x acceleration factor, for a predetermined period (for example, 100 hours), at an environmental temperature 90° C. The results are shown in Fig. 4. The lengths of the tree-like spikes are normalized by the length at three-times acceleration

20 of the glass material containing PbO.

TABLE 5

CONTENTS OF GLASS MATERIAL CONTAINING PbO	
PbO	60 -- 65 Wt %
B ₂ O ₃	5 -- 10 Wt %
SiO ₂	20 -- 20 Wt %
Softening Temp.: 575 ° C	

25 [0034] As apparent from Fig. 4, when the dielectric material contacting the ITO film (transparent conductive film) is formed of a glass material containing ZnO, none of the tree-like spikes were observed at a 1.5 -- 2.0 time acceleration test; on the other hand, at 2.5 -- 3.0 time acceleration tests the tree-like spikes were observed, however, the lengths of the spikes were much shorter than the case where the glass containing PbO was employed.

30 [0035] In the case where display electrodes X & Y were formed of NESA (SnO₂) in place of ITO, the similar results were obtained as well. That is, in the PDP having display electrodes X & Y formed of NESA as well it was confirmed that the glass material containing ZnO is suitable for the dielectric material.

35 [0036] In the above described preferred embodiment, owing to the employment of glass material having softening temperature lower than the softening temperature of lower layer 17A for the upper layer 17B, even if gas is generated in lower layer 17A during firing of upper layer 17B, the gas diffuses through upper layer to outside so that no gas is confined by upper layer 17B. Moreover, when a glass material whose softening speed is faster than that of lower layer 17B is employed for the material of upper layer 17B, upper layer 17B can be kept soft compared with lower layer 17A during firing of upper layer 17B; accordingly, the gas can be prevented in the same way from being confined by upper layer 17B.

40 [0037] In the above-described preferred embodiments, the material of each glass substrate 17A & 17B; the ratio of the respective thickness; the firing condition (temperature profile), etc. can be appropriately modified according to the glass substrate material; the coating material on the substrate surface; the material of transparent electrically conductive film 41 and the bus metal film material so that uniform dielectric layer 17 having a flat upper surface can be accomplished.

45 [0038] Though in the above preferred embodiment there was typically referred to a case where a PbO-containing glass was employed for the upper layer, upper layer 17B also can be formed of a ZnO-containing glass.

50 [0039] Moreover, though in the above preferred embodiment there was typically referred to a dielectric layer 17 of double-layer structure, it is not necessarily a double-layer structure. That is, it is possible for the dielectric layer 17 to be provided with a single-layer glass layer formed of a ZnO-containing glass. In this case, the materials and the condition are chosen by the balance of the disadvantages, such as the remaining of the foam in the glass material and the surface flatness, and the advantage that the process is simple. Selective employment of fine grain glass powder can contribute to improvement of the surface flatness.

55 [0040] Though in the above preferred embodiment there was typically referred to a case where the display electrode

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is formed of a transparent electrically conductive film and a metal film provided thereon it is needless to say that the present invention can be embodied in the case of the transparent electrically conductive film only having no metal film.

[0041] When the ZnO-containing glass is employed for the dielectric layer which contacts the transparent electrically conductive layer according to the present invention, the deterioration of the electrical resistance between display electrodes caused from electro-migration hardly takes place even during a long term operation of the PDP.

[0042] The dielectric layer of double layers such that the upper layer having its softening temperature lower than that of the lower layer allows only the upper layer to flow fluidly in forming the dielectric layer, and the chemical reaction of the lower layer with the display electrodes is controlled; therefore, there can be accomplished a dielectric layer having no large bubble, a flat surface and good transparency.

[0043] Moreover, chemical etching of the material of the ZnO-containing glass is easy; therefore, it can be employed as a coating layer, i.e. electrode terminal protecting layer, to protect, i.e. protection from oxidization, the electrode ends which are to become external connection terminals of the display electrodes during the fabrication steps of the PDP. That is, the employment of the ZnO-containing glass allows concurrent formation of the dielectric layer and the electrode terminal protection layer, so as to reduce the number of the fabrication steps.

Claims

1. An AC type plasma display panel (1) including, upon at least one of paired substrates for forming a discharge space (30), a plurality of display electrodes (X, Y) formed of a transparent electrically conductive film (41) or a multiple layer formed of a transparent electrically-conductive film plus a metal film (42) a width of which is narrower there than, and a dielectric layer (17) to cover said display electrodes from said discharge space, **characterized in that** :

said dielectric layer is a glass layer of double layer structure having a lower layer (17A) contacting said display electrodes and an upper layer (17B) not contacting said display electrodes;
said lower layer (17A) is formed of a ZnO-containing glass material containing substantially none of lead; and
said upper layer (17B) is formed of a PbO-containing glass material having a softening temperature lower than that of said lower layer.

2. A plasma display panel as recited in claim 1, said lower layer (17A) of said dielectric layer (17) being formed of a ZnO containing-glass material added with an alkaline metal oxide.

3. A plasma display panel as recited in claim 1 or 2, said ZnO-containing glass material including bismuth oxide.

4. A plasma display panel as recited in any of claims 1 to 3, said ZnO-containing glass material including a sodium oxide.

5. A plasma display panel as recited in any one of claims 1 to 4, a softening temperature of said lower layer (17A) material being 550°C to 600°C; and a softening temperature of said upper layer (17B) material being 450°C to 500°C.

6. A method of fabricating a plasma display panel as recited in any of claims 1 to 5, the method comprising:

a first step of forming said display electrodes (X, Y) upon said first substrate (11);
a second step of forming said lower layer (17A) so as to cover whole length of said display electrodes;
a third step of forming said upper layer (17B) so as to lie upon said lower layer;
a fourth step of providing a sealant (31) for sealing said first substrate and another second substrate (21), upon at least one of said substrates, so as to form said discharge space (30); thereafter, heating said sealant while said substrates being kept facing each other so as to melt to join each other; and
a fifth step of removing a portion of said lower layer, extending outward said panel beyond said joined area of the substrates, so as to expose ends (41a) of said display electrodes.

7. A method of fabricating a plasma display panel as recited in claim 6, said upper layer being formed, in said third step, upon a portion other than a portion extending outward said panel beyond said joined area of said substrates.

8. A method of fabricating a plasma display panel as recited in claims 6 or 7 **characterized in that**:

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after said lower layer (17A) is formed by firing said ZnO-containing glass material at a temperature near its softening temperature;
 said upper layer (17B) is formed by firing PbO-containing glass material at a temperature lower than said firing temperature of said lower layer.

5

Patentansprüche

1. Plasmaanzeigetafel (1) vom AC-Typ mit auf wenigstens einem Paar von Substraten zur Bildung eines Entladungs-
 10 raumes (30), einer Vielzahl von Anzeigeelektroden (X, Y), die aus transparentem elektrisch leitendem Film (41) oder einer Mehrfachsicht, die aus einem transparenten elektrisch leitenden Film plus einem Metallfilm (42), dessen Breite schmäler als die andere ist, gebildet ist, und einer dielektrischen Schicht (17) zum Bedecken der genannten Elektroden von dem Entladungsraum, **dadurch gekennzeichnet, daß:**
 - 15 die dielektrische Schicht eine Glasschicht von doppelschichtiger Struktur ist, die eine untere Schicht (17A) hat, welche die Anzeigeelektroden kontaktiert, und eine obere Schicht (17B), welche nicht die Anzeigeelektroden kontaktiert;
 die untere Schicht (17A) aus einem ZnO-enthaltenden Glasmaterial gebildet ist, welche im wesentlichen kein Blei enthält; und
 20 die obere Schicht (17B) aus einem PbO-enthaltenden Glasmaterial gebildet ist, welches eine Erweichungstemperatur unterhalb jener der unteren Schicht hat.
2. Plasmaanzeigetafel nach Anspruch 1, bei der die untere Schicht (17A) der dielektrischen Schicht (17) aus einem ZnO-enthaltenden Glasmaterial geformt ist, dem ein alkalisches Metalloxid hinzugefügt ist.
- 25 3. Plasmaanzeigetafel nach Anspruch 1 oder 2, bei der das ZnO-enthaltende Glasmaterial Wismuthoxid enthält.
4. Plasmaanzeigetafel nach einem der Ansprüche 1 bis 3, bei denen das ZnO-enthaltende Glasmaterial Natriumoxid enthält.
- 30 5. Plasmaanzeigetafel nach einem der Ansprüche 1 bis 4, bei der die Erweichungstemperatur des Materials der unteren Schicht (17A) 550°C bis 600°C beträgt und eine Erweichungstemperatur des Materials der oberen Schicht (17B) 450°C bis 500°C beträgt.
- 35 6. Verfahren zur Herstellung einer Plasmaanzeigetafel nach einem der Ansprüche 1 bis 5, welches Verfahren umfaßt:
 - einen ersten Schritt des Bildens der Anzeigeelektroden (X, Y) auf dem ersten Substrat (11);
 - einen zweiten Schritt der Bildung der unteren Schicht (17A), so daß sie die gesamten Längen der Anzeigeelektroden bedeckt;
 - 40 einen dritten Schritt der Bildung der oberen Schicht (17B), so daß sie auf der unteren Schicht liegt;
 - einen vierten Schritt des Vorsehens eines Versiegelungsmittels (31) zum Versiegeln des ersten Substrates und eines anderen zweiten Substrates auf wenigstens einem der genannten Substrate, um so den Entladungsraum (30) zu bilden; danach Erhitzen des Versiegelungsmittels während die Substrate einander zugewandt gehalten werden, um so zu schmelzen und sie miteinander zu verbinden; und
 - 45 einen fünften Schritt der Entfernung eines Teils der unteren Schicht, der sich außerhalb der Tafel jenseits des verbundenen Bereiches der Substrate erstreckt, um so Enden (41a) der Anzeigeelektroden zu exponieren.
7. Verfahren zur Herstellung einer Plasmaanzeigetafel nach Anspruch 6, bei dem die obere Schicht geformt wird, bei dem dritten Schritt, auf einem Abschnitt der ein anderer ist, als ein Abschnitt der sich von der Tafel nach außen jenseits des verbundenen Bereiches der Substrate erstreckt.
- 50 8. Verfahren zur Herstellung einer Plasmaanzeigetafel nach einem der Ansprüche 6 oder 7, **dadurch gekennzeichnet, daß:**
 - 55 nachdem die untere Schicht (17A) durch Brennen des ZnO-enthaltenden Glasmaterials bei einer Temperatur nahe seiner Erweichungstemperatur geformt worden ist;
 - die obere Schicht (17B) geformt wird durch Brennen von PbO-enthaltendem Glasmaterial bei einer Temperatur die niedriger ist als die Brenntemperatur der unteren Schicht.

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Revendications

1. Panneau d'affichage à plasma (1) de type alternatif, comprenant, sur au moins l'un de deux substrats destinés à former un espace de décharge (30), plusieurs électrodes d'affichage (X, Y) formées d'un film transparent conducteur de l'électricité (41) ou d'une couche multiple formée d'un film transparent conducteur de l'électricité avec un film métallique (42) dont la largeur est inférieure à celle du film précédent, et une couche diélectrique (17) destinée à recouvrir les électrodes d'affichage du côté de l'espace de décharge, **caractérisé en ce que :**
 - la couche diélectrique est une couche de verre à structure à deux couches ayant une couche inférieure (17A) qui est au contact des électrodes d'affichage et une couche supérieure (17B) qui n'est pas au contact des électrodes d'affichage, la couche inférieure (17A) est formée d'un matériau vitreux contenant ZnO et qui ne contient pratiquement pas de plomb, et la couche supérieure (17B) est formée d'un matériau vitreux contenant PbO ayant une température de ramollissement inférieure à celle de la couche inférieure.
2. Panneau d'affichage à plasma selon la revendication 1, dans lequel la couche inférieure (17A) de la couche diélectrique (17) est formée d'un matériau vitreux contenant ZnO avec une addition d'un oxyde alcalin.
3. Panneau d'affichage à plasma selon la revendication 1 ou 2, dans lequel le matériau vitreux contenant ZnO contient de l'oxyde de bismuth.
4. Panneau d'affichage à plasma selon l'une quelconques des revendications 1 à 3, dans lequel le matériau vitreux contenant ZnO contient de l'oxyde de sodium.
5. Panneau d'affichage à plasma selon l'une quelconques des revendications 1 à 4, dans lequel la température de ramollissement du matériau de la couche inférieure (17A) est comprise entre 550 et 600 °C, et la température de ramollissement du matériau de la couche supérieure (17B) est comprise entre 450 et 500 °C.
6. Procédé de fabrication d'un panneau d'affichage à plasma selon l'une quelconque des revendications 1 à 5, le procédé comprenant :
 - une première étape de formation des électrodes d'affichage (X, Y) sur le premier substrat (11),
 - une seconde étape de formation de la couche inférieure (17A) afin qu'elle recouvre toute la longueur des électrodes d'affichage,
 - une troisième étape de formation de la couche supérieure (17B) afin qu'elle soit disposée sur la couche inférieure,
 - une quatrième étape de disposition d'un matériau d'étanchéité (31) destiné à mettre en coopération étanche le premier substrat et un autre second substrat (21), sur l'un au moins des substrats, pour la formation de l'espace de décharge (30), puis de chauffage du matériau d'étanchéité lorsque les substrats sont maintenus en regard afin que le matériau soit fondu et raccorde les substrats, et
 - une cinquième étape d'enlèvement d'une partie de la couche inférieure, s'étendant vers l'extérieur du panneau au-delà de la région de raccordement des substrats afin que les extrémités (41a) des électrodes d'affichage soient exposées.
7. Procédé de fabrication d'un panneau d'affichage à plasma selon la revendication 6, dans lequel la couche supérieure est formée, au cours de la troisième étape, sur une partie autre qu'une partie qui s'étend à l'extérieur du panneau au-delà de la région de raccordement des substrats.
8. Procédé de fabrication d'un panneau d'affichage à plasma selon la revendication 6 ou 7, **caractérisé en ce que :**
 - après la formation de la couche inférieure (17A) par cuisson du matériau vitreux contenant ZnO à une température proche de sa température de ramollissement,
 - la couche supérieure (17B) est formée par cuisson du matériau vitreux contenant PbO à une température inférieure à la température de cuisson de la couche supérieure.

DECOMPOSITION PERSPECTIVE VIEW
OF A GENERAL SURFACE-DISCHARGE TYPE PDP



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CROSS-SECTIONAL VIEW ILLUSTRATING MAIN PORTION OF THE STRUCTURE
OF A PDP RELATED TO THE PRESENT INVENTION

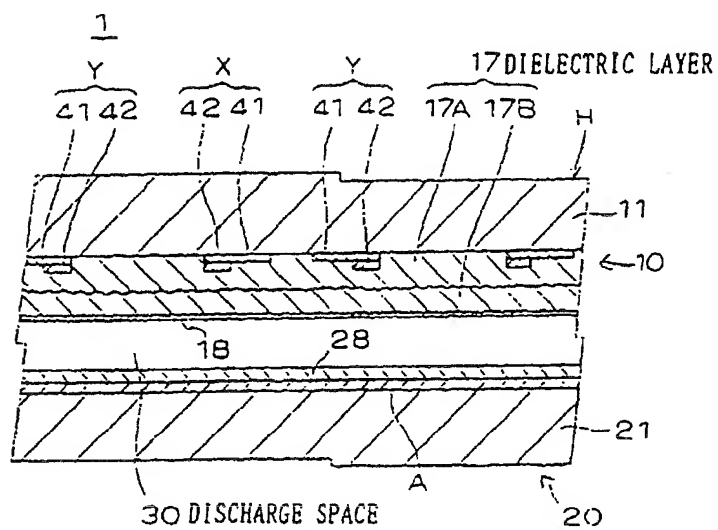
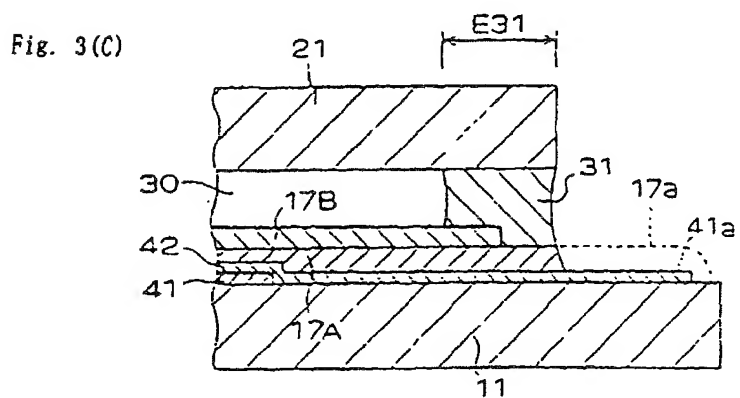
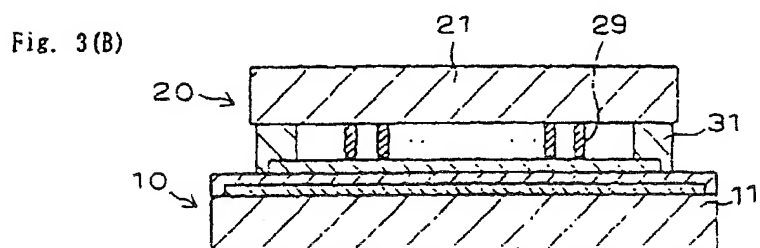
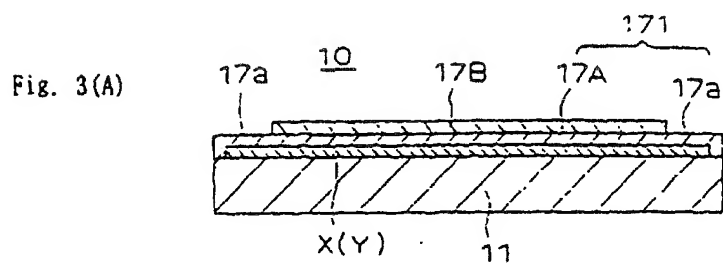


Fig. 2

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SCHEMATICAL ILLUSTRATION OF THE PDP AT MANUFACTURING STEPS



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GRAPH SHOWING THE RELATION
BETWEEN DETERIORATION OF ITO FILM AND THE DIELECTRIC MATERIALS

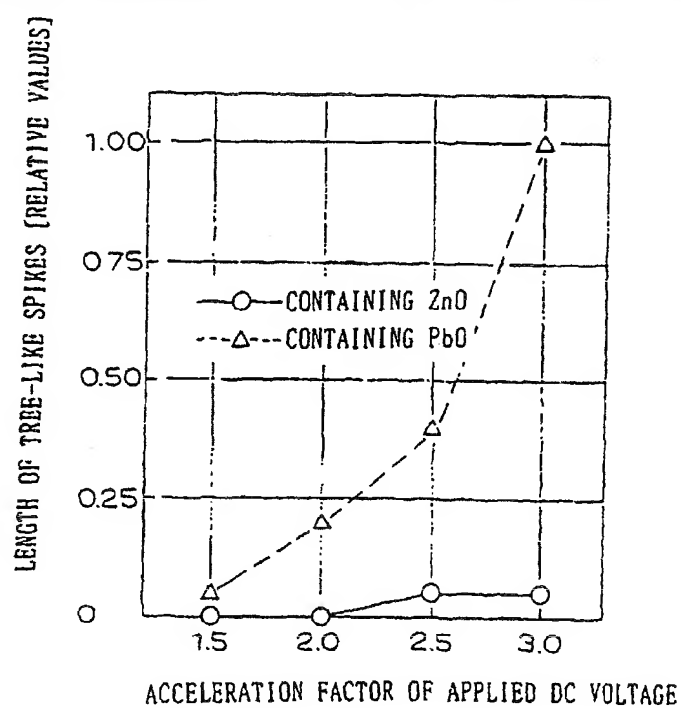


Fig. 4